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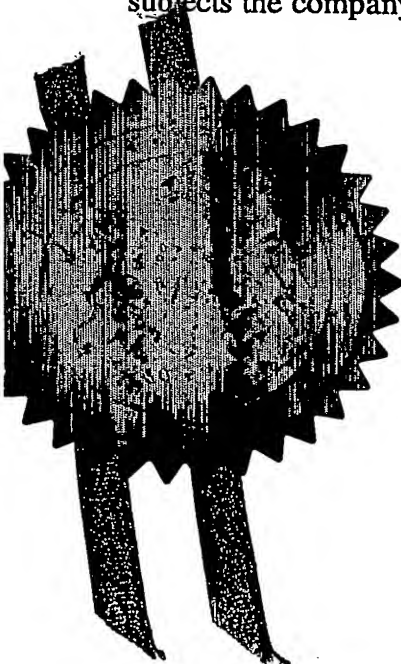
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Signed

*M. C. Pinkie*

Dated 27 August 2004

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# Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road  
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NP9 1RH

1. Your reference

REP07555GB

26AUG03 E832445-1 D02890  
P01/7700 0.00-0319799.3

2. Patent application number

(The Patent Office will fill in this part)

0319799.3

3. Full name, address and postcode of the or of each applicant (underline all surnames)

ITM POWER LTD  
VILLA FARM, JACK HAWS LANE  
BARNACK  
STAMFORD  
LINCS PE9 3DY

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

08461741001

4. Title of the invention

PHOTOVOLTAIC CELL

5. Name of your agent (if you have one)

Gill Jennings & Every

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

Broadgate House  
7 Eldon Street  
London  
EC2M 7LH

Patents ADP number (if you know it)

745002 ✓

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number  
(if you know it)

Date of filing  
(day / month / year)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
(day / month / year)

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if

YES

- a) any applicant named in part 3 is not an inventor, or
  - b) there is an inventor who is not named as an applicant, or
  - c) any named applicant is a corporate body.
- See note (d))

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# Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form

Description 3

Claim(s) 1

Abstract

Drawing(s) 1 + 1

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (*Patents Form 7/77*)

Request for preliminary examination and search (*Patents Form 9/77*)

Request for substantive examination (*Patents Form 10/77*)

Any other documents  
(please specify)

NO

11. For the applicant  
Gill Jennings & Every

I/We request the grant of a patent on the basis of this application.

Signature

Date

22 AUGUST 2003

12. Name and daytime telephone number of person to contact in the United Kingdom

ROBERT PERRY

020 7377 1377

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## Notes

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## PHOTOVOLTAIC CELL

### Field of the Invention

This invention relates to a photovoltaic cell.

### Background of the Invention

5        A photovoltaic cell converts light energy into electrical energy, the "photovoltaic effect" being the process through which light energy is converted into electrical energy. Photovoltaic cells are typically solid state devices, usually semiconductors such as silicon. Usually one or more photosensitive electrodes are irradiated, simultaneously generating a voltage and a current.

10       Electrochemical cells may be in the form of a membrane electrode assembly (MEA), i.e. a cathode/membrane/anode assembly. MEAs typically have a multi-layered structure comprising (i) an Ion Exchange Membrane (IEM), (ii) a current-collecting electrode, and (iii) an electro-catalyst layer on each side.

15       WO-A-03/023890 describes a composite MEA formed by an *in situ* polymerisation process. This publication further describes an MEA having an improved reaction interface.

### Summary of the Invention

20       The present invention addresses the need for an efficient method of generating electrical energy *via* the photovoltaic effect. The invention involves the use of a MEA capable of transmitting light.

A first aspect of the invention is a photovoltaic cell which is a membrane electrode assembly capable of transmitting light. The membrane material is preferably a polymer comprising a strongly ionic group. The assembly preferably comprises a catalyst and/or a dye sensitiser.

25       A second aspect of the invention is a method for generating a voltage, which comprises irradiating a cell of the invention.

### Description of the Preferred Embodiments

The term "photovoltaic cell" as used herein refers to a cell which is capable of converting light energy into electrical energy.

30       The term "membrane electrode assembly" as used herein refers to a cathode/membrane/anode assembly.

The membrane may be capable of transmitting light. For example, the membrane may comprise one or channels for the transmission of light or may be optically transparent, preferably optically clear. The membrane material may be transparent to photons, e.g. high energy, visible or UV radiation. It is preferably malleable, so that it can be formed into shapes which focus, concentrate and direct light as desired. Thus, for example, the MEA may be in the form of a light waveguide or lens.

The membrane material preferably comprises a polymer which includes a strongly ionic group. The membrane may be formed by the polymerisation of monomers which include monomers such as hydroxyethyl methacrylate (HEMA), acrylonitrile (AN), methyl methacrylate (MMA), 2-acrylamido-2-methyl-1-propanesulphonic acid (AMPSA) and/or vinyl pyrrolidone (VP).

The material may be formed by the copolymerisation of monomers which include an electrically active comonomer. The electrically active component can be based either upon an acid, e.g. a sulphonic acid ( $\text{SO}_3$ ), phosphoric or phosphonic acid, or an alkali (OH), e.g. KOH or NaOH or ammonium hydroxide. If electrically inactive comonomers are used, the material may be rendered electrically active by introducing strongly ionic molecules, for example using a swelling liquid technique.

Water can be used to cool the cell, maintain hydration and carry away excess energy as heat energy. Accordingly, the polymer is preferably hydrophilic, such that it is inherently able to absorb and transmit water throughout its molecular structure. Hydrophilic polymers can typically be formed by the copolymerisation from solution of a monomer mixture normally consisting of a hydrophobic/structural comonomer and a hydrophilic comonomer. The polymer is preferably cross-linked for greater stability. Cross-linked materials may be formed by applying ionising radiation to the material or by using a cross-linking agent. The use of additional cross-linking agents allows the final water uptake to be controlled separately from the electrical properties. The membrane may comprise integrated channels for the transmission of water.

The assembly may comprise a suitable catalyst. Preferred catalysts include platinum and titanium dioxide. A dye sensitiser such as ruthenium (II)

tris(2,2'-bipyridine)dichloride hexahydrate (ie. a compound of  $\text{Ru}(\text{bpy})_3^{2+}$ ), iodine or an iron complex with a suitable quenching compound (e.g. methyl violagen) may be used. Preferably, the sensitizer is disposed throughout the membrane. Any catalyst is preferably disposed on or near an electrode.

5        An electrode may be translucent, transparent (e.g. a tin oxide glass) or of an "open-weave" construction, to allow the transmission of photons through the electrode to reach the membrane. A carbon fabric may be used as an electrode, and the fabric may be impregnated with a layer of catalyst. The assembly may be in the form of a stack of individual MEAs.

10       Further information regarding suitable materials and processes for the formation of MEAs may be found in WO-A-03/023890.

The following Examples illustrate the invention.

#### Example 1

15       A cell of the invention was constructed using an AN-VP-AMPSA copolymer membrane. The electrode-catalyst systems used were tin oxide glass coated with titanium dioxide and carbon fabric coated with platinum. The cell is depicted in Figure 1.

20       A "blue" lamp (100 W electrical output) was used to illuminate the cell. The output of the cell was measured and was found to depend entirely on the presence of light, giving an open circuit voltage of 0.59 V. The resulting current was dependent upon the light flux, reaching a maximum of 0.22 mA/cm<sup>2</sup>.

#### Example 2

25       A cell similar to that of Example 1 was produced, except that the membrane was formed by thermal polymerisation of the monomers *in situ* with the glass electrode plate.

The cell was irradiated as before, giving an open circuit voltage of 0.78 V.

CLAIMS

1. A photovoltaic cell which is a membrane electrode assembly capable of transmitting light.
2. A cell according to claim 1, wherein the membrane is a material comprising a polymer, the polymer comprising a strongly ionic group.
3. A cell according to claim 2, wherein the polymer is hydrophilic.
4. A cell according to claim 2 or claim 3, wherein the polymer is cross-linked.
5. A cell according to any preceding claim, wherein the membrane is a malleable material.
6. A cell according to any preceding claim, wherein the assembly is in the form of a stack.
7. A cell according to any preceding claim, wherein the assembly comprises a catalyst.
8. A cell according to claim 7, wherein the catalyst comprises platinum and/or titanium dioxide.
9. A cell according to any preceding claim, wherein the membrane comprises a channel suitable for the transmission of light.
10. A cell according to any preceding claim, wherein the membrane is optically transparent.
11. A cell according to any preceding claim, wherein the assembly comprises a dye sensitiser.
12. A cell according to any preceding claim, wherein the assembly is planar in structure.
13. A cell according to any preceding claim, wherein an electrode is transparent.
14. A method for generating a voltage, which comprises irradiating a cell according to any of claims 1 to 13

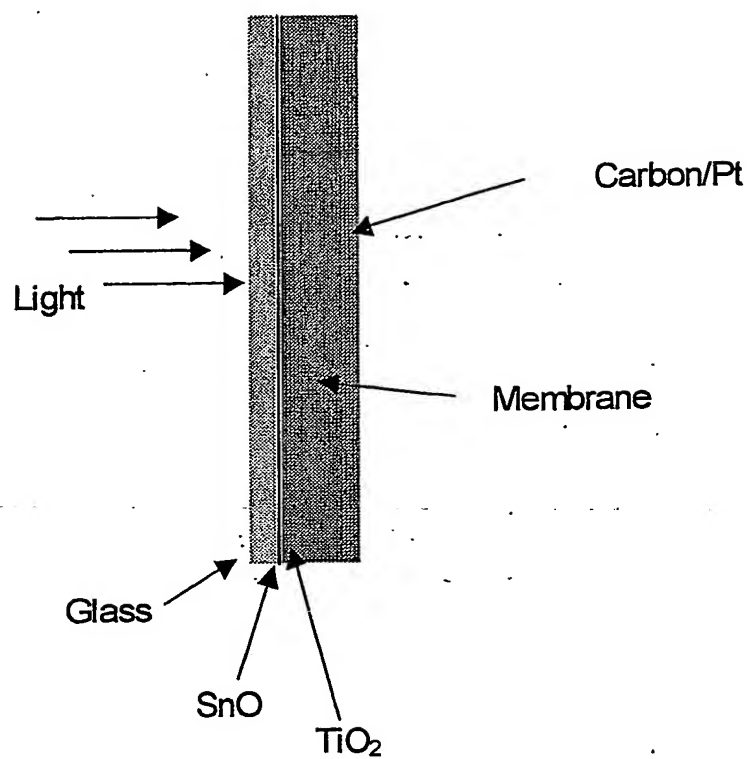


Figure 1